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MICROPATTERNED THERMOSENSOR

The present invention relates to a micropatterned thermosensor, in particular an infrared sensor, according to the definition of the species in the independent claims.

Background Information

Known infrared sensors, such as they are used in safety engineering, plant technology or in the household appliance industry, measure the temperature of a body from the infrared radiation it emits. Basically, the distinction is made among so-called pyroelectric, bolometric as well as thermoelectric sensors.

It is known to produce thermoelectric sensors using thin-film technology, for instance on polyimide foil. Furthermore, micropatterned thermosensors based on silicon technology are also generally known.

German Application DE 199 32 308.9 proposes, for instance, manufacturing a thermosensor in the form of a thermal column that is positioned on an at least substantially self-supporting membrane, the thermal contacts of this thermal column being designed to alternate as "hot" and "cold" thermal contacts and being connected to a supporting body by appropriate contact columns, as well as being electrically controllable via these contact columns. The German Application also proposes implementing the thermocouples running on the surface of the substantially self-supporting membrane in the form of circuit traces, which are alternately produced from a first and a second material, so that thermal contacts are created in the region where these two materials come in contact. The first material, in this case, is aluminum, while polysilicon is used as a second material.

The German Application DE 100 09 593.3 proposes designing a micropatterned thermosensor in the form of an infrared-sensor, for instance, using sacrificial layer technology or some other etching technology, by first creating a thin, self-supporting membrane on a silicon substrate, which is thermally decoupled from a subjacent substrate due to its low thermal conductivity, so that in response to incident infrared radiation, the membrane is warmed more than the substrate. A plurality of micropatterned sensor elements or thermocouples are then situated on the membrane, which thermoelectrically convert a temperature difference between the center of the membrane and the substrate into an electrical signal that is proportional thereto. In accordance with the German Application 100 09 593.3, the material combinations platinum/polysilicon, aluminum/polysilicon or p-type doped polysilicon/n-type doped silicon are used for the thermocouples created on the self-supporting membrane in the form of circuit traces. The material combination polysilicon/aluminum, which is used primarily in bulk micro-technology, has the advantage of being CMOS-compatible.

Lastly, it is known that gold, antimony, bismuth and lead tellurides may also be used as materials for thermocouples, with gold also being suitable for bulk micromechanics.

The object of the present invention is to devise a micropatterned thermosensor having improved sensitivity and stability at higher temperatures than the known micropatterned thermal sensors.

Summary of the Invention

Due to the patterning of the printed circuit traces on the supporting body and/or the particular choice of materials for the thermocouple, the micropatterned thermosensor according to the present invention has the advantage over the related art

of achieving a higher temperature sensitivity, without this entailing significant changes in the current manufacturing methods for micropatterned thermosensors. Specifically, according to the present invention, it is merely the layout of the produced printed circuit traces of the thermocouples and/or the material used for depositing these printed circuit traces that are/is modified.

It is furthermore advantageous that, through the choice of materials for the thermocouple, i.e. the material combination platinum or aluminum with doped or undoped polysilicon-germanium, the produced micropatterned thermosensor has a markedly increased temperature stability compared to known thermosensors using aluminum with polysilicon, for instance, as material for the thermocouple.

Through the choice of materials for the thermocouple, migration effects occurring at temperatures above 200° C may now also be avoided, and thus stability problems in the produced thermosensor, as often observed in sensors where polysilicon and aluminum are used as material for the thermocouple.

Furthermore, the aluminum widely used in known methods heretofore is an excellent thermal heat conductor, which means that the thermocouple manufactured therefrom has a relatively low thermoelectric effectiveness, whereas platinum, on the one hand, may be used at temperatures of up to 400° C and, on the other hand, has a thermal conductivity that is lower by a factor of 3 compared to aluminum. In contrast to polycrystalline silicon, polycrystalline, doped or undoped polysilicon-germanium also has a thermal conductivity that is lower by a factor of 3 to 8 and, therefore, also results in a markedly increased thermoelectric effectiveness of the produced thermocouple.

Advantageous further refinements of the present invention are derived from the measures indicated in the dependent claims.

In particular, an especially high increase in sensitivity and an especially good temperature stability of the thermosensor are achieved by a combination of the novel, meander-shaped or undulating-type layout of the micropatterned circuit traces on the surface of the supporting body and the mentioned special materials for the thermocouple.

It is also advantageous that, depending on the intended use of the micropatterned thermocouple, for instance, as an infrared sensor, the mentioned materials for the thermocouple may be combined with one another, using p-type doped or n-type doped material for the semiconductor material.

Since a temperature difference between so-called "hot" and "cold" contacts is thermoelectrically converted into a measurable electric voltage in micropatterned thermosensors, the "cold" points either must be kept at a constant temperature, or this temperature must be known or referenced relative to the temperature of the "hot" contact. Normally, for that purpose in known methods heretofore, so-called thermistors are integrated in hybrid technology on the supporting body for the thermocouple, since the employed materials, aluminum and polysilicon, are often not sensitive enough to determine this reference temperature.

When using platinum as thermoelectric material, it is then also advantageously possible in this context to integrate, or deposit, a high-precision, resistive temperature measuring element on the silicon chip, or the supporting body supporting the thermocouple, during the same manufacturing step as that for the corresponding printed circuit trace or conductor. This eliminates the need for an additional thermistor.

Implementing the printed circuit traces in the form of meander-shaped, or undulating-type printed circuit traces running on the supporting body, offers the further possibility of implementing only those printed circuit traces having the lower internal resistance in the form of meanders, since increased noise voltage results when a meander or undulating-type pattern is used in materials having a high electrical resistance.

It should also be emphasized that the meander-shaped or undulating-type circuit traces may be implemented as running side-by-side and also as overlapping or running one over another, at least regionally, in which case they must then be separated from one another in an electrically insulating manner by suitable insulating layers of oxides, for instance. If sufficient surface area is available, it is usually advantageous to configure the circuit traces side-by-side.

Lastly, it is now easily possible to also vary, or increase, the sensitivity of the resulting micropatterned thermosensor by varying the number of undulations or meanders. In this context, one utilizes the fact that the thermal resistance of a printed circuit trace increases with length, that is, the thermal resistance of a printed circuit trace having a meander pattern is greater than that of one using a corresponding straight-line pattern.

Brief Description of the Drawings

The invention is explained in greater detail in the following description with reference to the drawing. The figure shows a single thermocouple created on the surface of a supporting body in the form of deposited printed circuit traces running side-by-side.

Exemplary Embodiments

In the elucidated exemplary embodiment, the present invention is initially based on an infrared sensor, as is already proposed in the German Application DE 100 09 593.3. However, the infrared sensor it proposes is modified in two respects.

Specifically, as already proposed in the German Application DE 100 09 593.3, an at least substantially self-supporting membrane is created from a poorly heat-conducting material, such as an oxide, a nitride or a combination of both materials, on a substrate material having good heat-conducting properties, for instance, silicon. Preferably, this at least substantially self-supporting membrane, which is then used as supporting body 12 for a thermocouple 20 to be deposited thereon, is made of silicon dioxide, silicon nitride or of porous silicon.

A plurality of thermocouples 20 is then created on the surface of this supporting body 12. They are connected in series and arranged in a cross-pattern or star-pattern. According to the figure, which only shows one of these thermocouples 20, a first material 13 is first deposited on supporting body 12 in the form of a first, meander-patterned circuit trace 15, and a second material 14 is then deposited in the form of a second circuit trace 16, which is also meander-patterned. As shown in the figure, first circuit trace 15 and second circuit trace 16 run at least substantially parallel to one another.

It is also provided that first material 13 and second material 14 come in contact with one another in the region of a first thermal contact 10 and a second thermal contact 11, and that further conductors 17 leading to thermocouple 20 are provided, which are developed and deposited in an analogous fashion to second printed circuit trace 16, so that thermocouple 20 may be electrically interconnected to, or controlled by,

electronic components (not shown) via these conductors 17, in a generally known way.

Also shown in the figure is that first thermal contact 10 is exposed to a first temperature T_1, and second thermal contact 11 is exposed to a second temperature T_2. In this context, temperature T_2 is the actual temperature to be detected or measured by micropatterned thermosensor 5, while temperature T_1 is being kept at least approximately constant, or may alternatively be determined by an additional measuring device. In this respect, temperature T_1 of first thermal contact 10 ("cold" thermal contact) serves as a reference temperature for temperature T_2 of second thermal contact 11 ("hot" thermal contact), which is to be measured.

It should also be mentioned that the width of circuit traces 14, 15 and conductors 17 is between 20 nm and 200 μm, preferably between 1 μm and 20 μm. Their thickness is between 10 nm and 10 μm, preferably 100 nm and 2 μm. The first or second printed circuit traces 15, 16, respectively, as well as their meander patterning, and conductors 17 are fabricated in a known manner by sputter depositing or vapor depositing of the respective materials 13, 14, for instance through PECVD ("Physically Enhanced Chemical Vapor Deposition) or LPCVD ("Low Pressure Chemical Vapor Deposition").

In particular, first material 13 in the mentioned exemplary embodiment is n-type doted polysilicon-germanium, having a thermal conductivity of 3 to 8 w/km. Second material 14 in the discussed exemplary embodiment is platinum, having a thermal conductivity of 70 w/km. Furthermore, analogously to second circuit trace 16, conductor 17 is also in each case developed in the form of a platinum circuit trace, resulting in two thermocontacts 10, 11, both formed from the material combination of platinum/polysilicon-germanium.

Alternatively to the described exemplary embodiment according to the figure, first circuit trace 14 and second circuit trace 15 may also run over one another, regionally or entirely, and be electrically insulated from one another, except for thermal contacts 10, 11. In this case, the electrical insulation is assured by an oxidic, electrically insulating intermediate layer between circuit traces 15, 16.

Furthermore, instead of two thermal contacts 10, 11, a plurality of thermal contacts may also be obviously provided, which are configured in the manner of a thermal chain or a thermal column. In this case, at least two of the thermal contacts are then exposed to different temperatures.

In continuation of the refinement according to the first exemplary embodiment, in a further embodiment of the present invention, a part of a further measuring device is additionally created, or integrated, on supporting body 12 in the form of a circuit trace, in order to determine first temperature T_1. This eliminates the need to integrate the usual thermistor on the surface of supporting body 12 in the area of first thermal contact 10.

Specifically, this measuring device is then realized by providing an additional reference circuit trace made from platinum in one vicinity of first thermal contact 10 as sensitive component of this measuring device, this measuring device also being interconnected via appropriate conductors to generally known evaluation devices for determining a temperature-dependent electrical resistance of this reference circuit trace. This reference circuit trace is designed, for instance, analogously to conductor 17 or second circuit board conductor 16.

Alternatively, however, this measuring device may also be realized by using one segment of second circuit trace 16 or of conductors 17 as reference circuit trace and may be

interconnected to appropriate evaluating means for determining the temperature-dependent, electrical resistance of this part of the circuit trace.

This possibility of integrating an additional reference circuit trace on supporting body 12, or the possibility of using a part of second circuit trace 16 or of conductor 17 as reference circuit trace on supporting body 12 to measure or monitor temperature T_1, is the result of platinum's suitability for high-precision, resistive temperature measuring.

With respect to further details regarding the design of thermocouple 20 and the function and the further design of thermocouple 5 according to the figure, reference is made to the German Application DE 100 09 593.3, which describes this thermosensor 5, apart from the specific layout of circuit traces 15, 16 of thermocouple 20 and the particular choice of materials for thermocouple 20, in the form of an infrared sensor.